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<p>(54) Title: SHAPED MATERIALS DERIVED FROM ELONGATE BONE PARTICLES AND PROCESS FOR MAKING SAME</p> <p>(57) Abstract</p> <p>Surgically implantable shaped materials, e.g., sheets, are fabricated from elongate bone particles, advantageously those that have been demineralized. The materials when applied to a bone repair site enhance or accelerate new bone ingrowth by any one of a variety of biological and/or mechanical mechanisms.</p>		

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SHAPED MATERIALS DERIVED FROM ELONGATE
BONE PARTICLES AND PROCESS FOR MAKING SAME

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BACKGROUND OF THE INVENTION

This invention relates to surgically implanted materials fabricated from bone particles and, more particularly, to such materials which are made up of a coherent mass of elongate bone particles.

The use of demineralized bone powder in the repair of bone defects has been a subject of investigation for some time. Bone powder contains one or more substances, possibly bone morphogenic protein (BMP), which induce bone regeneration at the defect site. See, e.g., Covey et al., "Clinical Induction of Bone Repair with Demineralized Bone Matrix or a Bone Morphogenetic Protein", Orthopaedic Review, Vol. XVII, No. 8, pp. 857-863 (August, 1989). According to Habal et al., "Autologous Corticocancellous Bone Paste for Long Bone Discontinuity Defects: An Experimental Approach", Annals of Plastic Surgery, Vol. 15, No. 2, pp. 138-142 (Aug. 1985), autogenous bone which has been granulated into a pastelike material and combined with autogenous blood has been used in the repair of long bone defects in dogs.

U.S. Patent No. 5,073,373 discloses a deformable, shape-sustaining osteogenic composition, suitable as a filler for osseous defects, in which particles of demineralized bone are uniformly distributed within a carrier which is a liquid polyhydroxy compound such as glycerol. The vast majority of the demineralized bone particles possess random, irregular geometries with an average median length to median thickness ratio of from about 1:1 to about 3:1.

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- 1 Commonly assigned U.S. Application Serial No.
07/830,934 discloses a flowable osteogenic composition
containing entangled demineralized bone particles of
relatively high median length to median thickness ratio.
5 The flowable osteogenic composition can possess a paste-like
or putty-like consistency as well as a liquid or runny
consistency.

SUMMARY OF THE INVENTION

- 10 It is an object of this invention to provide
shaped materials fabricated from elongate bone particles and
a process for making such materials.

- It is another object of this invention to provide
shaped materials fabricated from combinations of bone
15 particles and one or more additives such as plasticizers,
flexibilizing agents, biostatic/biocidal agents, fillers,
binders, bonding agents, surface active agents,
medically/surgically useful substances, and the like.

- In keeping with these and related objects of this
20 invention, a shaped material is provided which comprises a
coherent mass of elongate bone particles.

- The foregoing shaped material, e.g., in the form
of a sheet, can be formed by applying a liquid slurry of
elongate bone particles, e.g., filaments or fibers, to a
25 porous support, draining excess liquid from the bone
particles, optionally while applying a compressive force to
the particles during and/or after drainage of the excess
liquid, to provide a coherent, shaped wetted mass of bone
particles and, optionally, drying the wetted mass. The
30 material thus formed is relatively rigid when dry and, upon

1 contact with a biocompatible liquid, e.g., water, saline
solution, etc., becomes pliable and flexible.

Application of the foregoing shaped material to
the site of a bone defect, e.g., one resulting from injury,
5 infection, malignancy or developmental malformation, leads
to new bone ingrowth by one or more biological mechanisms
such as osteogenesis, osteoconduction and/or osteoinduction
or by one or more physical mechanisms such as constituting a
physical barrier to soft tissue ingrowth, providing a
10 support or scaffolding for new bone growth, etc.

The term "osteogenic" as applied to the material
of this invention shall therefore be understood as referring
to the ability of the material of this invention to
participate in the process of new bone growth regardless of
15 the mechanism(s) involved.

The term "coherent" as applied to the mass of
elongate bone particles refers to the ability of the bone
particles to adhere to each other either mechanically, e.g.,
by entanglement, or by use of a biocompatible adhesive
20 whether the shaped material containing the bone particles is
in the dry or wetted, e.g., hydrated, state.

The term "shaped" as applied to the bone material
of this invention shall be understood as referring to a
determined or regular form or configuration, in contrast to
25 an indeterminate or vague form or configuration (as in the
case of a "lump" or other solid mass of no special form) and
is characteristic of such materials as sheets, plates,
disks, cones, pins, screws, and the like.

The term "rigid" shall be understood to refer to
30 the relatively stiff, inflexible and somewhat brittle nature

1 of the shaped materials of this invention while in the dry,
i.e., unwetted, state.

The term "flexible" shall be understood to refer
to the ability of the shaped material to become pliable upon
5 being wetted or hydrated with a suitable biocompatible
liquid and thus more readily conformable to a bone repair
site.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 The elongate bone particles employed in the shaped
materials of this invention are generally characterized as
having relatively high median length to median thickness
ratios, e.g., at least about 50:1 and preferably at least
about 100:1 and, similarly, relatively high median length to
15 median width ratios, e.g., at least about 10:1 and
preferably at least about 50:1. Such particles can be
readily obtained by any one of several methods, e.g., by
milling or shaving the surface of an entire bone or
relatively large section of bone. Thereafter, the resulting
20 elongate bone particles can be optionally demineralized as
discussed herein.

Employing a milling technique, particles ranging
in median length from about 2 up to about 200 mm or more (as
in the case of the long bones), in median thickness from
25 about 0.05 to about 2mm and in median width from about 1 to
about 20mm can be readily obtained. Another procedure for
obtaining the elongate bone particles herein, particularly
useful for pieces of bone of up to about 100 mm in length,
is the Cortical Bone Shredding Mill available from Os .
30 Processing Inc., 3303 Carnegie Avenue, Cleveland, Ohio
44115. Use of this bone mill results in the production of

1 long, thin strips which quickly curl lengthwise to provide tubular-like bone particles.

Depending on the procedure employed for producing the elongate bone particles, one can obtain a mass of bone
5 particles containing at least about 60 weight percent, preferably at least about 70 weight percent and most preferably at least about 80 weight percent of bone particles possessing a median length of from about 2 to about 200 mm or more and preferably from about 10 to about
10 100 mm, a median thickness of from about 0.05 to about 2 mm and preferably from about 0.2 to about 1 mm and a median width of from about 1 mm to about 20 mm and preferably from about 2 to about 5 mm. These bone particles can possess a median length to median thickness ratio of at least about
15 50:1 up to about 500:1 or more and preferably from about 50:1 to about 100:1 and a median length to median width ratio of from about 10:1 to about 200:1 and preferably from about 50:1 to about 100:1.

If desired, the mass of elongate bone particles
20 can be graded into different sizes to reduce or eliminate any less desirable size(s) of particles which may be present. In overall appearance, the elongate bone particles can be described as filaments, fibers, threads, slender or narrow strips, etc. As already noted and depending on the
25 manner in which they are produced, these elongate particles may have a tendency to curl to provide tubular-like particles. The bone particles can be obtained from cortical, cancellous and/or corticocancellous bone which may be of autogenous, allogenic and/or xenogeneic origin.
30 Porcine bone is a particularly advantageous type of

1 xenogeneic bone tissue which can be used as a source for the
elongate demineralized bone particles of this invention.

Following the shaving, milling or other technique
whereby they are obtained, the elongate bone particles are
5 optionally subjected to demineralization in order to reduce
their inorganic content to a low level, e.g., to not more
than about 5% by weight of residual calcium and preferably
to not more than about 0.5% by weight residual calcium.
Demineralization of the bone particles will ordinarily
10 result in producing particles of slightly smaller
dimensions.

The elongate bone particles can be demineralized
in accordance with known and conventional procedures. In a
preferred demineralization procedure, the elongate bone
15 particles are subjected to a defatting/ disinfecting step
which is followed by an acid demineralization step. A
preferred defatting/disinfectant solution is an aqueous
solution of ethanol, the ethanol being a good solvent for
lipids and the water being a good hydrophilic carrier to
20 enable the solution to penetrate more deeply into the bone
particles. The aqueous ethanol solution also disinfects the
bone by killing vegetative microorganisms and viruses.
Ordinarily at least about 10 to about 40 weight percent by
weight of water (i.e., about 60 to about 90 weight percent
25 of defatting agent such as alcohol) should be present in the
defatting/disinfecting solution to produce optimal lipid
removal and disinfection within the shortest period of time.
The preferred concentration range of the defatting solution
is from about 60 to about 85 weight percent alcohol and most
30 preferably about 70 weight percent alcohol. Following
defatting, the bone particles are immersed in acid over time

1 to effect their demineralization. Acids which can be
employed in this step include inorganic acids such as
hydrochloric acid and organic acids such as peracetic acid.
After acid treatment, the demineralized bone particles are
5 rinsed with sterile water for injection to remove residual
amounts of acid and thereby raise the pH. At this point
some entanglement of the wet demineralized bone particles
will result. The wet demineralized bone particles can then
be immediately shaped into a shaped osteogenic material in
10 accordance with the method of this invention or stored under
aseptic conditions, advantageously in a lyophilized state,
for processing at a later time.

The elongate bone particles can be admixed with
one or more substances such as adhesives, fillers,
15 plasticizers, flexibilizing agents, biostatic/biocidal
agents, surface active agents, binding and bonding agents,
fillers, and the like, prior to, during, or after shaping
the particles into a desired configuration. Suitable
adhesives, binding agents and bonding agents include acrylic
20 resins, cellulose, bioresorbable polymers such as
polyglycolide, polylactide, glycolide-lactide copolymer,
etc. Suitable fillers include bone powder, demineralized
bone powder, hydroxyapatite, etc. Suitable plasticizers and
flexibilizing agents include liquid polyhydroxy compounds
25 such as glycerol, monacetin, diacetin, etc. Suitable
biostatic/biocidal agents include antibiotics, povidone,
sugars, etc. Suitable surface active agents include the
biocompatible nonionic, cationic, anionic and amphoteric
surfactants.

30 If desired, the bone particles can be modified in
one or more ways, e.g., their protein content can be

- 1 augmented or modified as described in U.S. Patent Nos.
4,743,259 and 4,902,296. Any of a variety of medically
and/or surgically useful substances can be incorporated in,
or associated with, the bone particles either before, during
5 or after fabrication of the shaped articles disclosed
herein. Thus, e.g., one or more of such substances can be
introduced into the demineralized bone particles, e.g., by
soaking or immersing the bone particles in a solution or
dispersion of the desired substance(s).
- 10 Medically/surgically useful substances which can
be readily combined with the demineralized bone particles
and/or osteogenic material of this invention include, e.g.,
collagen, insoluble collagen derivatives, etc., and soluble
solids and/or liquids dissolved therein, e.g., antiviri-
15 cides, particularly those effective against HIV and
hepatitis; antimicrobials and/or antibiotics such as
erythromycin, bacitracin, neomycin, penicillin, polymyxin B,
tetracyclines, viomycin, chloromycetin and streptomycins,
cefazolin, ampicillin, azactam, tobramycin, clindamycin and
20 gentamicin, etc.; biocidal/biostatic sugars such as
dextroal, glucose, etc.; amino acids, peptides, vitamins,
inorganic elements, co-factors for protein synthesis;
hormones; endocrine tissue or tissue fragments;
synthesizers; enzymes such as collagenase, peptidases,
25 oxidases, etc.; polymer cell scaffolds with parenchymal
cells; angiogenic drugs and polymeric carriers containing
such drugs; collagen lattices; antigenic agents;
cytoskeletal agents; cartilage fragments, living cells such
as chondrocytes, bone marrow cells, mesenchymal stem cells,
30 natural extracts, tissue transplants, bone, demineralized
bone powder, autogenous tissues such blood, serum, soft

1 tissue, bone marrow, etc.; bioadhesives, bone morphogenic
proteins (BMPs), transforming growth factor (TGF-beta),
insulin-like growth factor (IGF-1); growth hormones such as
somatotropin; bone digestors; antitumor agents; immuno-
5 suppressants; permeation enhancers, e.g., fatty acid esters
such as laureate, myristate and stearate monoesters of
polyethylene glycol, enamine derivatives, alpha-keto
aldehydes, etc.; and, nucleic acids. The amounts of such
optionally added substances can vary widely with optimum
10 levels being readily determined in a specific case by
routine experimentation.

To prepare the shaped osteogenic materials of this
invention, a quantity of elongate bone particles, preferably
those that have been demineralized, slurried in a suitable
15 liquid, e.g., water, organic protic solvent, aqueous
solution such as physiological saline, etc., and optionally
containing one or more biocompatible ingredients such as
adhesives, fillers, plasticizers, flexibilizing agents,
biostatic/biocidal agents, surface active agents,
20 medically/surgically useful substances, etc., as previously
described, is applied to a form such as a flat sheet, mesh
screen or three-dimensional mold and excess liquid is
removed, e.g., by being drained away. This procedure is
referred to herein as "wet-laying." For example, in the
25 case of a sheet, the thickness of the layer of wetted bone
particles can vary widely, e.g., from about 1 to about 40
mm. Some particle entanglement results from the wet-laying
operation. Further particle entanglement, if necessary or
desirable, can be effected by the use of water jets or other
30 suitable mechanical entangling methods. Either before or
after the wet-laying procedure, one or more additional

1 substances can be added to the bone particles, e.g.,
thixotropic agents, therapeutic agents, and the like, as
previously mentioned. The wet demineralized bone particles
are then dried either in an oven at a temperature of from
5 about 30° to about 70°C, preferably from about 30° to about
40°C, or by lyophilization in accordance with procedures and
conditions that are well known in the art, e.g., a shelf
temperature of from about -20 to about -35°C, a vacuum of
from about 150 to about 100 mTorr for a time of from about 4
10 to about 48 hours depending on the mass. In an alternative
embodiment herein, the entangled mass of bone particles can
be subjected to a compressive force, e.g., of up to about
100 psi, during and/or after the wet-laying step and/or
while the drained but still wet shaped article is being
15 dried. The resulting shaped material is rigid and
relatively strong when dry and flexible and pliable when
wetted or hydrated.

At the site of implantation, the shaped article
can be employed in the dry state or, where site conformation
20 is desired, in the hydrated state. The dry or hydrated
article can be cut or sized if need be to conform to a site
being repaired. The article can be hydrated with a suitable
biocompatible liquid, e.g., water, saline solution, etc.,
for a period of time ranging from about 1 to about 120
25 minutes depending on the density of the shaped material.
After being hydrated, the shaped material becomes flexible
yet retains its shape and much of its strength. The shaped
material of this invention can be packaged in either the
dried or wet state and stored for subsequent application.
30 In some circumstances, it is preferable to package the

1 material in the wet state so that it is ready for immediate
use at the surgical site.

The shaped materials of this invention can be
utilized in a wide variety of orthopaedic, neurosurgical and
5 oral and maxillofacial surgical procedures such as the
repair of simple and compound fractures and non-unions,
external and internal fixations, joint reconstructions such
as arthrodesis, general arthroplasty, cup arthroplasty of
the hip, femoral and humeral head replacement, femoral head
10 surface replacement and total joint replacement, repairs of
the vertebral column including spinal fusion and internal
fixation, tumor surgery, e.g. deficit filling, discectomy,
laminectomy, excision of spinal cord tumors, anterior
cervical and thoracic operations, repair of spinal injuries,
15 scoliosis, lordosis and kyphosis treatments, intermaxillary
fixation of fractures, mentoplasty, temporomandibular joint
replacement, alveolar ridge augmentation and reconstruction,
inlay bone grafts, implant placement and revision, sinus
lifts, etc. These materials can be sutured or stapled in
20 place for anchoring purposes and serve in guided tissue
regeneration or as barrier materials.

The following examples are illustrative of the
preparation of composition containing elongate demineralized
bone particles and the fabrication of a shaped sheet
25 material from the composition.

EXAMPLE 1

A section of allogenic cortical bone
approximately 9 cm long and 10-30 mm wide was placed in the
30 hopper of a Cortical Bone Shredding Mill of Os Processing,
Inc., 3303 Carnegie Avenue, Cleveland, Ohio 44115 equipped

1 with a 20-flute rotary cutter. The mill was operated at a
speed of about 120 rpm until approximately 100 to 1000 g of
mass of bone particles of which at least 80 weight percent
5 was made up of particles having a median length of about 10
mm and a median thickness of about 0.5 mm was obtained. The
elongate bone particles were then placed in a reactor. A 70
weight percent ethanol solution at a rate of 30 milliliters
per gram of bone particles was introduced into the reactor
followed by agitation for 1 hour (Bolander et al., Journal
10 of Bone and Joint Surgery, Vol. 68-A, No. 8 (Oct. 1986)) to
effect defatting and disinfecting of the bone particles.
Following drainage of the ethanol, a 0.6N solution of HCl at
15 ml per gram of bone was introduced into the reactor
(Bolander et al., supra), the reaction proceeding for 3
hours (Glowackie, AATB Workshop, 11th Annual meeting (1987)).
Following drainage of the HCl, the bone particles were
covered and rinsed three times with water for injection
(WFI) with the WFI being replaced at 5 minute intervals.
Following drainage of the WFI, the bone particles were
20 completely covered with 0.1M sodium phosphate, a procedure
which was repeated until the pH of the solution fell between
6.8 and 7.4. The rinsing procedure with WFI was repeated to
provide a composition containing wet demineralized, elongate
bone particles containing not more than about 0.5 weight
25 percent residual calcium.

EXAMPLE 2

A quantity of the composition containing wet
demineralized bone particles from Example 1 was spread out
30 on a tight-mesh screen to a depth of 10mm to form a flat
sheet with dimensions of 5 inches by 5 inches while excess

1 liquid drained off through the screen. The entire surface
was subjected to about 8psi and the load was maintained
while the sheet was oven-dried. The resultant rigid sheet
was approximately 5 mm in depth, brittle to some extent, and
5 had significant tensile strength. A 2 inch by 2 inch
portion of the sheet was cut off with scissors and immersed
in water for injection for 15 minutes. The sheet
approximately doubled in thickness after this time. The
piece was now significantly more pliable and could be bent
10 in a circular fashion so that the opposite sides met. The
integrity of the structure was not visibly affected by this
bending and the piece returned to its original shape upon
release. A sheet material which is more pliable or less
pliable can be accomplished by changing the initial
15 thickness of the particles during the wet-lay process or by
varying the compression force.

EXAMPLE 3

The hydrated sheet of Example 2 is applied to an
20 osseous defect site using an instrument such as forceps.
The ability of the foregoing shaped material to maintain its
shape and position in the aqueous environment of the body is
superior to a like quantity of demineralized bone powder.

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1 WHAT IS CLAIMED IS:

1. A shaped material comprising a coherent mass of elongate bone particles.
2. The shaped material of Claim 1 wherein the
5 bone particles are demineralized.
3. The shaped material of Claim 1 exhibiting osteogenic activity.
4. The shaped material of Claim 1 wherein the bone particles are demineralized, the shaped material
10 exhibiting osteogenic activity.
5. The shaped material of Claim 1 wherein at least about 60 weight percent of the bone particles possess a median length of from about 2mm to about 200mm, a median thickness of from about 0.05 mm to about 2 mm and median
15 width of from about 1 mm to about 20 mm.
6. The shaped material of Claim 1 wherein at least about 60 weight percent of the bone particles possess a median length of from about 10 mm to about 100 mm, a median thickness of from about 0.02 mm to about 1 mm and a
20 median width of from about 2 mm to about 5 mm.
7. The shaped material of Claim 1 wherein at least about 60 weight percent of the bone particles possess a median length to median thickness ratio of from about 50:1 to about 500:1 and a median length to median width ratio of
25 from about 10:1 to about 200:1.
8. The shaped material of Claim 1 wherein at least about 60 weight percent of the bone particles possess a median length to median thickness ratio of from about 50:1 to about 100:1 and a median length to median width ratio of
30 from about 50:1 to about 100:1.

1 9. The shaped material of Claim 1 wherein the
bone particles are obtained from cortical, cancellous and
corticocancellous bone of autogenous allogenic and xenogenic
origin.

5 10. The shaped material of Claim 1 wherein the
bone particles are obtained from porcine bone.

11. The shaped material of Claim 1 further
comprising one or more additives selected from the group
consisting of plasticizers, flexibilizing agents, biostatic
10 agents, biocidal agents, surface active agents, binding and
bonding agents and fillers.

12. The shaped material of Claim 1 further
comprising at least one additional ingredient selected from
the group consisting of antiviral agent, antimicrobial
15 agent, antibiotic agent, amino acid, peptide, vitamin,
inorganic element, protein synthesis co-factor, hormone,
endocrine tissue, synthesizer, enzyme, polymer-cell
scaffolding agent with parenchymal cells, angiogenic drug,
demineralized bone powder, collagen lattice, antigenic
20 agent, cytoskeletal agent, mesenchymal stem cells, bone
digester, antitumor agent, cellular attractant, fibronectin,
growth hormone cellular attachment agent, immunosuppressant,
nucleic acid, hydroxy apatite and penetration enhancer.

13. The shaped material of Claim 1 in the form of
25 a flat sheet, curved sheet, plate, disk, cone, pin, screw or
tube.

14. A method of fabricating shaped material from
elongate bone particles which comprises:

applying a liquid slurry of elongate bone
30 particles to a porous support; and,

1 draining excess liquid from the bone particles to
provide a coherent shaped wetted mass of bone particles.

5 15. The method of Claim 14 further comprising the
step of compressing the demineralized bone particles during
and/or after drainage of the excess liquid.

16. The method of Claim 14 further comprising the
step of drying the demineralized bone particles after
drainage of the excess liquid.

10 17. The method of Claim 15 further comprising the
step of drying the demineralized bone particles during
and/or after compression of the particles.

15 18. The method of Claim 15 wherein the
demineralized bone particles are compressed under a force
ranging from about 0.5 to about 100 pounds per square inch
of surface area.

19. The method of Claim 14 wherein the bone
particles are demineralized.

20 20. The method of Claim 14 wherein the shaped
material exhibits osteogenic activity.

21. The method of Claim 14 wherein the bone
particles are demineralized, the shaped material exhibiting
osteogenic activity.

25 22. The method of Claim 14 wherein at least about
60 weight percent of the bone particles possess a median
length of from about 2mm to about 200mm, a median thickness
of from about 0.05 mm to about 2 mm and a median width of
from about 1 mm to about 20 mm.

30 23. The method of Claim 14 wherein at least about
60 weight percent of the demineralized bone particles
possess a median length of from about 10 mm to about 100 mm,

1 a median thickness of from about 0.2 mm to about 1.0 mm and
a median width of from about 2 mm to about 5 mm.

24. The method of Claim 14 wherein at least about
60 weight percent of the bone particles possess a median
5 length to median thickness ratio of from about 50:1 to about
500:1 and a median length to median width ratio of from
about 10:1 to about 200:1.

25. The method of Claim 14 wherein at least about
60 weight percent of the bone particles possess a median
10 length to median thickness ratio of from about 50:1 to about
100:1 and a median length to median width ratio of from
about 50:1 to about 100:1.

26. The method of Claim 14 wherein the bone
particles are obtained from cortical, cancellous and
15 corticocancellous bone of autogeneous, allogenic and
xenogeneic origin.

27. The method of Claim 14 wherein the bone
particles are obtained from porcine bone.

28. The method of Claim 14 wherein the bone
20 particles are demineralized.

29. The method of Claim 14 wherein the bone
particles are entangled.

30. A method of enhancing new bone ingrowth at a
bone repair site which comprises applying to the bone repair
25 site shaped material comprising a coherent mass of elongate
bone particles.

31. The method of Claim 30 wherein the shaped
material further comprises one or more additives selected
from the group consisting of plasticizers, flexibilizing
30 agents, biostatic agents, biocidal agents, surface active
agents, binding and bonding agents and fillers.

1 32. The method of Claim 30 wherein the shaped
material further comprises at least one additional
ingredient selected from the group consisting of antiviral
agent, antimicrobial agent, antibiotic agent, amino acid,
5 peptide, vitamin, inorganic element, protein synthesis co-
factor, hormone, endocrine tissue, synthesizer, enzyme,
polymer-cell scaffolding agent with parenchymal cells,
angiogenic drug, bone, demineralized bone powder, autogenous
tissue, collagen lattice, antigenic agent, cytoskeletal
10 agent, mesenchymal stem cells, bone digester, antitumor
agent, cellular attractant, fibronectin, growth hormone
cellular attachment agent, immunosuppressant, nucleic acid,
hydroxy apatite and penetration enhancer.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 94/14138A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61L27/00 A61K35/32

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 483 944 (EL GLENDER) 6 May 1992 see claims; examples 1-4 ---	1-10
X	EP,A,0 555 807 (MATSUMOTO DENTAL COLLEGE) 18 August 1993 see claims ---	1-4
X	GB,A,2 175 807 (AMERICAN HOSPITAL SUPPLY CORPORATION.) 10 December 1986 see claims; example ---	1,2
P,X	US,A,5 314 476 (ANNAMARIE B. PREWETT ET AL.) 24 May 1994 cited in the application see claims; examples 1-2 ---	1-32
-/--		



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

17 March 1995

Date of mailing of the international search report

29.03.95

Name and mailing address of the ISA

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Fax (+ 31-70) 340-3016

Authorized officer

ESPINOSA, M

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 495 284 (OSTEOTECH, INC.) 22 July 1992 see claims; examples ---	1
A	EP,A,0 413 492 (OSTEOTECH, INC.) 20 February 1991 see claims; example ---	1
A	EP,A,0 419 275 (OSTEOTECH, INC.) 27 March 1991 cited in the application see claims & US,A,5 073 373 ---	1
A	THE LANCET, vol.1, no.8227, 2 May 1981, LONDON GB pages 959 - 962 GLOWACKI J. ET AL. 'APPLICATION OF THE BIOLOGICAL PRINCIPLE OF INDUCED OSTEOGENESIS FOR CRANIOFACIAL DEFECTS.' see the whole document -----	1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 94/ 14138

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 30-32
because they relate to subject matter not required to be searched by this Authority, namely:
Remark: Although claims 30 to 32 are directed to a method of treatment of the human/animal body, the search has been carried out and based on the alleged effects of the composition.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US 94/14138

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0483944	06-05-92	US-A-	5306304	26-04-94
EP-A-0555807	18-08-93	JP-A-	5220214	31-08-93
		JP-A-	5220211	31-08-93
GB-A-2175807	10-12-86	US-A-	5053049	01-10-91
		DE-A-	3617898	04-12-86
		FR-A-	2582516	05-12-86
		JP-A-	62032966	12-02-87
US-A-5314476	24-05-94	NONE		
EP-A-0495284	22-07-92	US-A-	5236456	17-08-93
		JP-A-	4246359	02-09-92
EP-A-0413492	20-02-91	US-A-	5061286	29-10-91
		JP-A-	3178665	02-08-91
EP-A-0419275	27-03-91	US-A-	5073373	17-12-91
		US-A-	5290558	01-03-94
		DE-D-	69016331	09-03-95
		JP-C-	1851817	21-06-94
		JP-A-	3210270	13-09-91
		US-A-	5298254	29-03-94
		US-A-	5284655	08-02-94
US-A-5073373	17-12-91	DE-D-	69016331	09-03-95
		EP-A-	0419275	27-03-91
		JP-C-	1851817	21-06-94
		JP-A-	3210270	13-09-91
		US-A-	5290558	01-03-94
		US-A-	5298254	29-03-94
		US-A-	5284655	08-02-94